Dihadron fragmentation functions and high Pt hadron-hadron correlations

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One of the most promising signatures for the formation of a quark gluon plasma (QGP) in a heavy-ion collision has been that of jet quenching. This phenomenon leads to the suppression of high p_T particles emanating from such collisions. Such jet quenching phenomena have been among the most striking experimental discoveries from the Relativistic Heavy Ion Collider (RHIC) at Brookhaven National Laboratory.

In the investigation of jet suppression, correlations between two high p_T hadrons in azimuthal angle are used to study the change of jet structure. While the back-to-back correlations are suppressed in central $Au+Au$ collisions, indicating parton energy loss, the same-side correlations remain approximately the same as in $p+p$ and $d+Au$ collisions. Given the experimental kinematics, this is considered as an indication of parton hadronization outside the medium. However, since the same-side correlation corresponds to two-hadron distribution within a single jet, the observed phenomenon is highly nontrivial. To answer the question as to why a parton with a reduced energy would give the same two-hadron distribution, one has to take a closer look at the single and double hadron fragmentation functions and their modification in medium.

In an effort to study the process without the complication of final state interactions, we will focus on the following semi-inclusive process

$$e^+ + e^- \to \gamma^* \to h_1 + h_2 + X$$

of e^+e^- annihilation [1]. In the limit of very large Q^2 of the reaction, we may invoke a parton model like picture. Under this approximation, at leading twist, the factorization of the two-hadron inclusive cross section into a hard total partonic cross section σ_0 and the double inclusive fragmentation function $D_q^{h_1h_2}(z_1,z_2)$ may be assumed, *i.e.* ,

$$\frac{d^2\sigma}{dz_1dz_2} = \sum_q \sigma_0^{q\bar{q}}\left[D_q^{h_1h_2}(z_1,z_2) + D_{\bar{q}}^{h_1h_2}(z_1,z_2)\right]. \quad (1)$$

The rigorous justification of this factorization and the ensuing evolution will be presented in a subsequent effort [2].

Evaluating the cross section at NLO and factoring out the e^+e^- annihilation cross section we may obtain the DGLAP evolution equations as

$$\frac{\partial D_{NS}^{h_1h_2}(Q^2)}{\partial \log Q^2} = \frac{\alpha_s}{2\pi}\left[P_{q\to qg} * D_{NS}^{h_1h_2}(Q^2) + \hat{P}_{q\to qg} \bar{*} D_{NS}^{h_1}(Q^2) D_g^{h_2}(Q^2) + 1 \to 2\right] \quad (2)$$

In the interest of simplicity we specialize to the case of the non-singlet fragmentation function. Within the framework of the parton model we can picture the process as the free propagation of a parton followed by its fragmentation into hadrons of which two are identified. Fragmentation may be preceded by the radiation of multiple soft gluons (this is the top line of the above equation. Occasionally the parent parton undergoes a semi-hard split into two offspring partons which then propagate freely of each other and then fragment independently into hadrons and one hadron from each of these offspring is identified. Prior to their fragmentation, the offspring may radiate multiple soft gluons as well. In the above equation $P_{q\to qg}$ is the regular splitting function of the DGLAP equation renormalized for double differential cross section, whereas $\hat{P}_{q\to qg}$ is the same without a virtual correction.

The above equation may be solved numerically and results for the case of $z_1 = 2z_2$ are presented in Fig. 1. In keeping with the spirit of the experimental data, results for the ratio of the double to the single fragmentation function are presented. We assume a simple ansatz for the initial condition at $Q^2 = 2$ GeV^2 *i.e.* $D_{NS}^{h_1h_2}(z_1,z_2) = D^{h_1}(z_1)D^{h_2}(z_2)$. We present results for the evolution with $\log(Q^2)$ at intervals of 1. Our numerical results show little change of the ratio as Q^2 is varied over a wide range of values. This is consistent with the minimal change observed in the same side two hadron correlations in experiments.

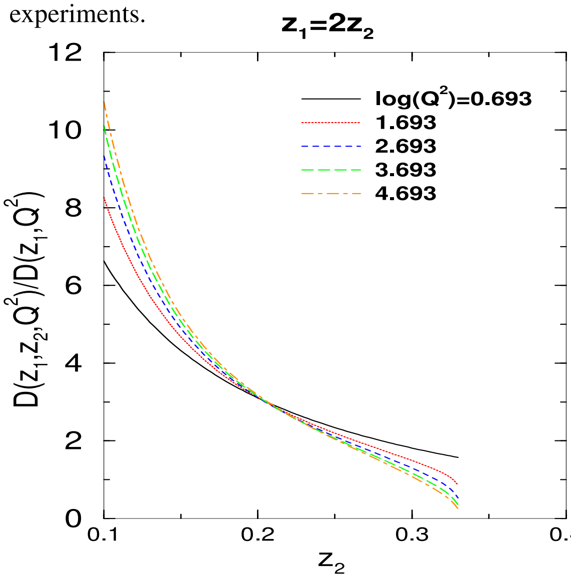

FIG. 1: Results of the ratio of the non-singlet quark dihadron fragmentation function $D_q^{h_1h_2}(z_1,z_2,Q^2)$ to the single leading fragmentation function $D_q^{h_1}(z_1,Q^2)$. Results are presented from $Q^2 = 2\text{GeV}^2$ to 109GeV^2 for $z_1 = 2z_2$.

[1] A. Majumder, J. Phys. G. *to appear* (2004).
[2] A. Majumder and X.-N. Wang, Phys. Rev. D. *to appear* (2004).